JMM: Journal of Mechanical and Manufacture
Vol. 3 No 2, April 2024 , pp. 120-131
DOI:
e-ISSN: 2829-4424

DESIGN OF BELT CONVEYOR FOR CORN COB SHELLER AND CHOPPER MACHINE

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Abstract
The use of a belt conveyor is one of the choices of facilities or tools used to transport or move materials or as a means of transporting materials, both bulk materials and individual materials. One of the machines that requires a conveyor is a corn cob sheller and chopper machine which was created in 2022. by Majalengka University students. This tool has a problem, namely, the corn that has been shelled cannot automatically go straight into the chopping machine, so a design is needed that takes into account the safety factor and the correct conveyor speed. This is of course for safety and ensures that the conveyor can transport corn which has a density of 760 kg/m 3 at a slope of 300 ‰. For this reason, the conveyor that best suits these needs must have specifications with a total belt length of 0.295 m, drum pulley diameter of 3 in or 0.0762 m, shaft diameter of 20 mm with a length of 500 mm, 150 watt electric motor drive, 16T small sprocket gear and 24T large sprocket with chain number 35. Safety Factor (SF) on the Belt Conveyor frame has a minimum SF value of 6.3, with a maximum tension of 32.5 N/mm2 and yield strength of 204 N/mm2 and a belt speed of 0.5 m/s.
Keywords: *Belt Conveyor, Safety Factor, Shelling Machine, Corn Cob, Chopper Machine.*

Submitted: 2024-03-01	Revised: 2024-03-01	Accepted: 2024-04-01

Introduction

Most industrial processes cannot be separated from moving objects or materials from one place to another. These activities will certainly take time and require energy if carried out continuously. therefore a tool is made in the form of a conveyor belt or better known as a conveyor. The use of Belt Conveyor is one of the choices of means or tools used to transport or move material or as a means of material transportation, either bulk material or unit material.

One of the machines that requires a conveyor is a corn cob sheller and chopper machine that was made in 2022 by Majalengka University students. As the name implies, this machine has two functions at once in one machine process, namely shelling and chopping corn cobs. However, this tool has a problem, namely, corn that has been peeled cannot automatically enter the chopping machine. On that basis, this tool is still very possible to be developed. One of them is by adding a conveyor to transport the corn chips. The conveyor on this tool will be useful for distributing the results of corn shells into the chopping machine. The type of conveyor belt that has serrations or better known as cleated Belt Conveyor is very suitable for transporting fine and grained bulk materials such as corn.

Based on the above, the author will conduct a research with the title "design of Belt Conveyor on corn cob sheller and chopper machine). Tool design is the process of developing tools, methods and techniques to improve manufacturing efficiency and productivity by preparing specialized machines and tools for current machine requirements. Economic and quality factors will ensure competitive product prices. Since tools cannot answer all manufacturing processes, tool design is a dynamic problem (Hoffman, 1996).

According to Setiawan, 2021, The use of belt conveyors is one of the choices of means or tools used to transport or move materials or as a means of material transportation, both bulk materials and unit materials. Belt conveyor is the most commonly used tool because it can transport small and large capacity materials. We can find this use in many industries ranging from coal mining, cement industry, fertilizer industry and food industry.

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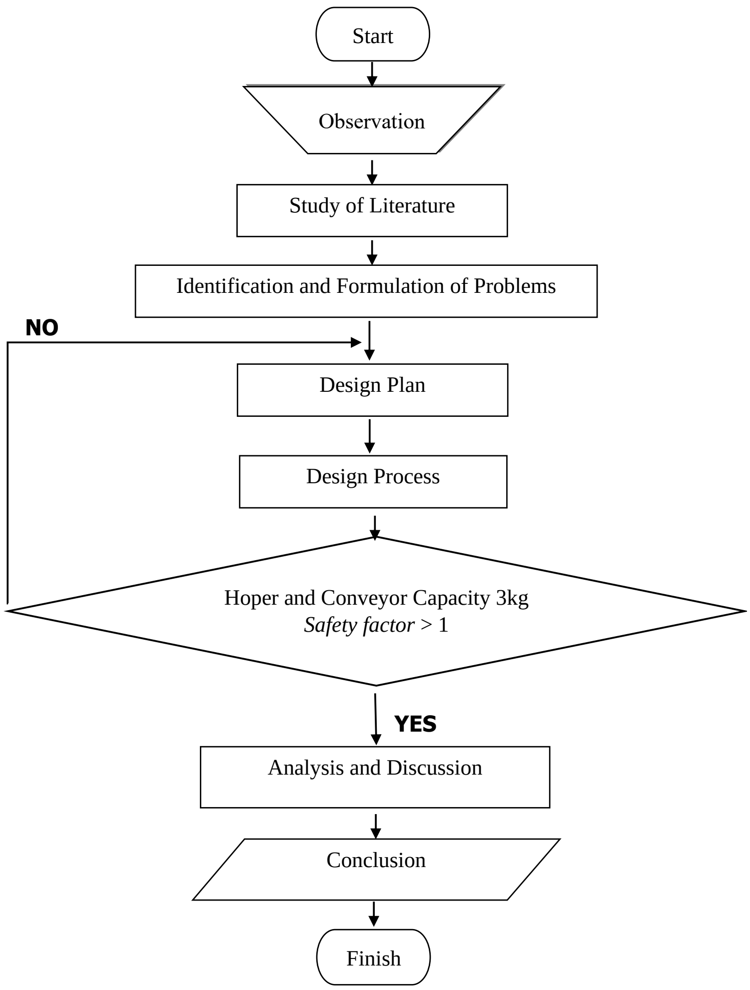
According to Raisul, 2022, as the name implies, this machine has two functions at once in one machine process, namely shelling and chopping corn cobs. But this tool has a problem, namely, corn that has been peeled cannot automatically go directly into the chopping machine.

According to Lepold Harbovsky, 2021, The type of belt conveyor that has serrations or better known as cleated belt conveyor is very suitable for transporting fine and grained bulk materials such as corn. The choice of cleat spacing is influenced by the length of the belt and the slope of the distribution path. For this reason, the design process determines whether this conveyor can be used optimally.

According to Zhang a, 2010, Design aims to minimize failures in the manufacturing process and will certainly be able to easily estimate power consumption and material requirements. Increased efficiency can also be achieved by designing the appropriate speed on the conveyor. By planning the appropriate speed, the power consumption can also be estimated and maybe even minimized.

According to Robert, 2012, In the design can not be separated from the safety factor or better known as FOS (Factor Of safety). The factor of safety is the ratio of the absolute strength of the structure (structural capability) to the actual load given which is usually denoted from 1.25-4

Research Method



a. Observation,
Observing the corn cob sheller and chopper machine in the Faculty of Engineering Workshop at Majalengka University and seeing the shelling process directly.
b. Literature study,
Reading reports in the Majalengka University library about the results of tests on Raisul Islam Yoga's corn cob sheller and chopper, reading articles about types of conveyors on the internet.
c. Identification and formulation of problems,
The author identifies and formulates problems related to the conveyor design process on the corn cob sheller and chopper machine and finds a problem where the results of corn husks do not automatically enter the chopper machine.
d. Intial plan,
The author determines the length of the conveyor to be made based on observations on the sheller machine, plans the appropriate belt width, calculates and plans the transport capacity, determines the drive motor that will be used by determining the required power, determines the diamete of the drive pulley on the conveyor based on the predetermined belt speed and based on the rotation of the drive motor, plans the shaft diameter on the pulley, plans the appropriate gear sprocket and chain, selects the bearings to be used in accordance with the calculations that have been made.
e. Design process,
After going through the calculations in the initial design plan, the author will immediately describe all parts of the conveyor belt, starting from the drive pilley frame, tail pullet, drive motor, bearing hopper, chain, and sprocket as well as additional accessories on the belt in the form of cleated. In this design process using solidwoks software.
f. Hopper and belt capacity 3kg, frame Safety Factor >1,
The author will use the analysis and calculation of the design results as well as the calculation of several components and image simulations. The safety factor must be more than one, which means that the load received must not be greater than the strength of the material to be used. In this section, the research can be continued if it meets the calculation standards made, but if it has not reached the test standards, it will process to the initial design plan.
g. Analysis and discussion,
After meeting the standards, the author will describe the results of the design process that is in accordance with the calculation standards made.
h. Conclusion,
The author will collect data that has been obtained from a series of designs so that conclusions are obtained.

Results and Discussion

Figure 4.1 *Belt Conveyor* Concept

Predefined initial design data:

Initial Design Data Table

Conveyor length (l)	=	135 cm = 1,35 m
Belt width (B)	=	0,28 m
Density of corn (y)	=	760 kg/m3
Drum Puley Diameter (D)	=	3 in = 7,62 cm
Sudut kemiringan konveyor	=	30^0
Cleat height	=	2,5 cm

A. Belt Planning

1) Belt weight per meter (qb)

Based on table 2.1 about the belt layer, the cover thickness on the load side δ1 = 1.5 mm is obtained, the cover thickness on the poll carrier side δ2 = 1 mm, and for the number of belt layers (i) based on table 2.5, namely 3 layers, so that the belt weight per meter can be determined by the following equation:

qb = 1,1 B (1,15 x i + δ1+ δ2)

qb = 1,1 x 0,28 (1,15 x 3 + 1,5 + 1)

qb = 1,833 kg/m

2). Finding the Cross-Sectional Area of the Belt (A)

To determine the value (K), you must first find the Surcharge angle using the equation:

$$Tan\ x = \frac{\text{cleat height}}{\text{B}/2}$$

$Tan\ x = \frac{2{,}5\ \text{cm}}{28\text{cm}/2}$

$Tan\ x = 0{,}178$

$x = Tan^{-1}\ 0{,}178$

$x = 10^0$

Because the surcharge angle is 100, the value of K = 0.0295 is obtained (Table 2.3), the cross-sectional area of the belt can be calculated with the following equation:

A = K (0,9B-0,05)2

A = 0,0295 (0,9 x 0,28 -0,05)2

A = 0,0295 (0,252 – 0,05)2

A= 0,0295 x 0,2022

A = 0,001203718 m2

3) Calculating the required belt length (L):

$$L = \frac{D + d}{2} \pi + 2c$$

$L = \frac{7{,}62cm + 7{,}62cm}{2}\ 3{,}14 + 2\ (135cm)$

$L = 7{,}62\text{cm}\ .3{,}14 + 270\text{cm}$

$L = 295\ cm$

$L = 2{,}95\ m$

4) Conveyor Speed Design

Finding belt speed based on the capacity formula as follows:

$$Qt = 3600 \text{ x A x V x y x S}$$

$V = \frac{Qt}{3600 \text{ x A x y x S}}$

$V = \frac{0.929}{3600 \text{ x } 0{,}001203718 \text{ x } 0{,}77575 \text{ x } 0{,}56}$

$V = \frac{0{,}929}{1{,}8825}$

$V = 0{,}5$ m/s

5) Power required by the conveyor

Load Weight Per Unit Length (Wm)

$$Wm = \frac{Qt}{0{,}06 \text{ V}}$$

$Wm = \frac{0{,}258\ kg/s}{0{,}06\ .\ 0{,}5}$

$Wm = 0{,}516$ kg/m

6) Finding the Weight of Material Transfer

$$W = Wm \text{ x } l$$

W = 0,516 x 1,35

W = 0,6966 kg

7) Conveyor Belt Resistance

Top Side Restraint Force:

$$W3\text{-}4 = (W + qb + Wm)\ L\ \omega + (W + qb)H$$

W3-4 = (0,6965 + 1,83 + 0,516) 2,95 x 0,018 + (0,6965 + 1,83)0,77

W3-4 = 2,1 kg

Bottom side Restraint Force:

Before calculating the resistance force on the bottom side, you must first find the weight of idler rotating parts per meter (q "p) in the following way:

Weight idler rotating parts:

$$G''p = 10B + 3 \text{ kg}$$

G”p = 10 x 0,28 + 3 kg

G”p = 5,8 kg

Roller weight per meter:

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$q"p = \frac{G'p}{l}$

$q"p = \frac{5,8}{1,35}$

$q"p = 4,3$ kg/m

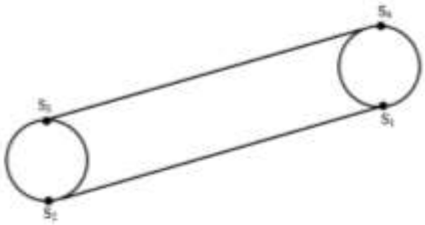
After obtaining the q "p value, the lower side resistance force is:

W1-2 = (qb + q"P) L ω - qb.H

W1-2 = (1,83 + 4,3) 2,95 x 0,018 – 1,85 x 0,77

W1-2 = 16,659 kg

8) Pull/tension on the belt



Voltage S2 can be determined as follows:S2 = S1 + W1-2

S2 = S1 + 16,659

Stress S3, friction resistance on the pulley ranges from 5-7% so that it can be determined by the following equation:

S3 = 1,07 S2

S3 = 1,07 (S1 + 16,659)

S3 = 1,07 S1 +17,82513

Stress S4, is the stress where the material is dropped at the end of the conveyor so it can be determined as follows:

S4 = S3 + W3-4

S4 = 1,07 (S1 + 17,82513) + 2,1

S4 = 107S1 + 19,92513 …………equation 1

From Euler's law, the belt does not slip on the pulley if it satisfies the equation:

St ≤ Ssleμa

Where

St = Tensile force on the tight side of the belt (S4)

Ssl = Tensile force on the reversing belt side (S1)

μ = coefficient between belt and pulley

a = Contact angle on the belt

e = Basic logarithm numbers

S4 ≤ S1 x 1,87 ……………… equation 2

From equations 1 and 2 we get:

S1 . 1,87 ≥ 1,07S1 + 21,1728891

0,8S1 ≥ 21,1728891

S1 ≥ 26,46

S1 = 26,5

Equation to find S2, S3, S4

S2 = S1 + 16,659

S2 = 26,5 + 16,659

= 43,159
S3 = 1,07 (S1 + 16,659)
S3 = 1,07 . 43,159
= 46,18013
S4 = S3 + W3-4
S4 = 1,07 (S1 + 16,659) + W3-4
S4 = 46,18013 + 2,1
= 48,28013

B. Drive motor power

In determining the drive motor, the following equation can be used:

$$p = \frac{Wo\ .V}{102\ \eta}$$

To find Wo, the following equation is used:

$$Wo = S_4 - S_1 + Wdr$$

Wo = 48,28013 - 26,5 +2,24
Wo = 24,02013 kg
Meanwhile, to find Wdr using the equation:

$$Wdr = 0{,}03\ (S_4 + S_1)$$

Wdr = 0,03 (48,28013 + 26,5)
Wdr = 0,03 x 74,78013
Wdr = 2,24 kg

$$P = \frac{Wo\ .V}{102\ \eta}$$

$$P = \frac{24{,}02013\ .\ 0{,}5}{102\ .\ 0{,}8}$$

$$P = \frac{12{,}01}{81{,}6}$$

$$P = 0{,}147\ Kw$$

$$P \approx 0{,}15\ Kw$$

So the planned motor power for the conveyor is 0.15Kw

C. Gear Sprocket Planning

1) Determining the Large Sprocket Rotation

$$V = \frac{\pi . D . n2}{60}$$

$$n2 = \frac{60V}{\pi . D}$$

$$n2 = \frac{60\ x\ 0{,}5}{3{,}14\ x\ 0{,}0762}$$

$$n2 = 125{,}38\ Rpm$$

$$n2 \approx 125\ Rpm$$

2) Determining the Sprocket Teeth

In determining the sprocket to be used for conveyors with a drive motor rotation (N1) of 200 Rpm and a shaft rotation on a drum pulley (N2) of 125 Rpm, first plan the gear sprocket on the drum pulley with a number of teeth of 24, then to determine the small sprocket using the following equation

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$$Nt1 = N2\frac{n2}{\mathrm{n1}}$$

$Nt1 = 24\frac{125}{200}$

$Nt1 = 10{,}9$

3) Chain Selection

After obtaining the number of teeth of the large sprocket 24 (24T) and the small sprocket 16 (16T) which is increased from the previous 13.8. Then from Figure 2.8 the chain corresponding to number 50 is obtained

D. Determining the shaft diameter

1) Determining the Torsional Moment

Where :

Pd = (P x fc) Kw
= 0,15 Kw x 1,2
= 0,18 Kw

N = 115 Rpm

Then:

$T = 9{,}74 \times 10^5 \times \frac{0{,}18}{125}$

T = 1402,56 kg.mm

2) Allowable Stress of Materials

The material that will be used for this shaft is S45C alloy steel with a tensile strength value of 58 kg / mm2 which has a Safety Factor of 6-9, so the allowable stress obtained is:

$ta = \frac{\sigma}{Sf1 \; x \; Sf2}$

$t_a = \frac{58}{6 \; x \; 3}$

$t_a = 3{,}2 \; kg/mm^2$

3) Shaft Diameter

$ds = (\frac{5{,}1}{ta}Kt..T)1/3$

$d_s = (\frac{5{,}1}{3{,}2}1{,}5.1{,}2.\; 1402{,}56)^{1/3}$

$d_s = 4023{,}6^{1/3}$

$d_s = 15{,}9$ mm

$d_s = 16$ mm

So the minimum shaft diameter that can be used is 16 mm.

E. Frame Simulation Process

The test steps carried out are seen as follows:

1) Preprocessing

Preprocessing merupakan langkah awal dalam melakukan simulasi, tahap ini terdiri dari beberapa tahapan diantaranya: modeling, pemilihan jenis simulasi yang akan dilakukan, memilih bahan material, pembuatan geometri (fixture), menentukan jenis beban yang akan di simulasikan, membuat meshing dan memasukan parameter-parameter yang dibutuhkan dalam simulasi.

a) Modeling

The modeling stage is the initial part of designing the frame design with dimensions that are adjusted based on the design concept calculation. The following is a modeling of the Belt Conveyor frame.

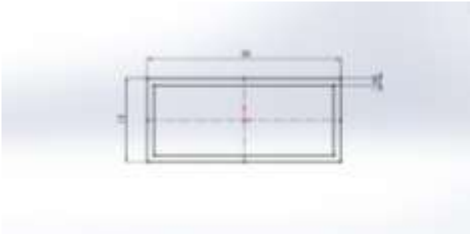

Figure 4.3 Hollow Iron 35x15 mm

Figure 4.4 Frame with Hollow Iron 35x15 mm

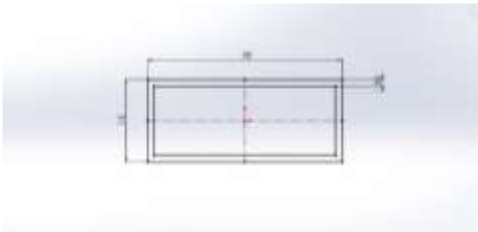

Figure 4.5 Hollow Iron 40x20 mm

Figure 4.6 Frame with Hollow Iron 40x20 mm

b) Select a simulation type

At this stage, the type of simulation that will be simulated in solidworks software is selected, namely the type of static simulation The following is a picture of the selection ofthe type of static simulation in solidwork software.

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Figure 4.7 Selection of simulation type

c) Material Type Selection

The material used in this frame is galvanize steel with the following specifications:

Figure 4.8 Material Type Selection

d) The type of pedestal chosen in this test is fixed geometry because in this test there is a pedestal that does not move, and for the selected pedestal is in the following figure:

Figure 4.9 Selection of the type of support in the simulation

e) Load Type Selection

The load selected on the Belt Conveyor frame is burdened by the maximum pull due to the conveyor from the design calculation of 48 kg or 47072 Newton.

f) Meshing

The mesh process is a software analysis based on the element method. The following is the mesh process on the Belt Conveyor frame.

2) Run Simulation

At the simulation run stage, it is a sumulation obtained from preprocessing that produces stress and factor of safety.

3) Post Processing

This process is the final stage of the simulation where the results of the simulation are obtained.

a) Stress

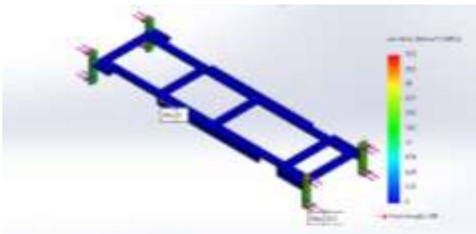

Figure 4.10 stress simulation results

Belt Conveyor frame stress with a maximum stress number of 32.5 N / mm² (MPa) is found in the loading of the sheller knife connection and the sheller drum, with the maximum Yield Strength on this material reaching 204 N / mm² (MPa) which means that the frame is still feasible from the view of stress because it is still far from the Yield Strength limit is still able to withstand the maximum load given.

b) Safety Factor (SF)

Figure 4.11 FoS Simulation Result

The safety factor is very important in the process of designing a product, to determine whether the product is arman or not safe to use the following are the results of the SF of the machine frame. The SF value of the designed Belt Conveyor frame has a minimum price of 6.3. From the Safety factor value obtained, it is very safe in accordance with the definition quoted from the book "machine elements" by Ir. Hery Sonawan, namely, the safety factor must be greater than 1.

By comparison, the load given is smaller than the yerid stenght material. So that this Belt Conveyor frame can be made because it has met the safety factor in the design in solidworks software.

Conclusion

1. After calculating and designing the Belt Conveyor on the corn cob sheller and chopper machine, the specifications of the machine elements are obtained as follows:

Bagian Conveyeor	Ukuran	Keterangan
Conveyor Length	1,35 Meter	Ditetapkan
Belt Length	2,95 Meter	Dihitung
Cleat Height	0,025 Meter	Ditetapkan
Ø Drum Pulley	0,0762 Meter	Ditetapkan
Ø Shaft	0,016 Meter	Dihitung
Shaft length	0,5 Meter	Ditetapkan
Gear Sproket 1	10	Dihitung
Gear Sproket 2	24	Dihitung

2. After the calculation, the power required to move the conveyor belt is 150 Watt.
3. Safety Factor (SF) on the Belt Conveyor frame has a minimum SF value of 6.3, with a maximum material stress of 204 N / mm2 and yield Strength 32.5 N / mm2, so that the frame that has been designed is safe to use.

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